Art. XVIII.—*The Want of a Uniform System in Experimenting upon Timber.*

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As the strength of timber varies not only according to the tree from which it is taken, but also in accordance with a number of minor conditions which affect it often in a very marked degree, it is evident that unless such conditions be fully and carefully recognised and recorded in connection with any series of experiments upon timber, comparison with other experiments will be impossible, and what otherwise might be valuable work will be rendered almost useless.

The great importance of this subject was impressed upon me very forcibly when collecting information some time ago as to the strength of colonial timbers, and as this interesting field of investigation has as yet been barely entered upon in these colonies, and as much of the work hitherto done suffers from the omission of the details referred to, the present has appeared to me a seasonable opportunity of bringing the matter before this Society, and endeavouring to secure the co-operation of the members in an attempt to introduce some system as a guide for future workers in this direction.

The most important of the minor conditions referred to as affecting the strength of timber are as follow :—(1) Age of tree; (2) nature of locality where grown; (3) part of tree from which timber is taken; (4) length of time seasoned; (5) deflection as affecting the bending moment of a beam; (6) size of piece tested. To each of these conditions I will allude in the order given.

1. *Age of tree.*—In relation to this point, it is only of consequence to know that the piece for experiment has been taken from a tree neither in its earlier nor later stages of existence, for in the former the wood is imperfectly formed, soft, and weak, while in the latter it has entered upon a process of decay; it is in the intermediate or mature stage that the wood is fitted for use practically, and should supply specimens for the purpose of experiment.

2. *Locality where grown.*—The geological nature of the place where the tree grows has a very great influence upon the character of the timber formed. Trees growing in a

moist, low-lying situation will produce, as might be expected, a very different class of timber from that obtained from the same species when found upon a dry and barren ridge. It also appears to me, from a comparison of experiments, that the closer any particular kind of tree approaches equatorial regions the stronger is the timber which it produces. Whether this is a general rule or not I am unable to say, but it would not be unreasonable to suppose that it is so, when it is recollected that the strongest timbers in the world are produced in the tropics, as witness the krangi of Borneo, the ironwood of Burmah, the West Indian mora, and the ironbark of Northern Queensland.

3. *Part of tree from which timber is taken.*—Of the core, the sapwood, and the heartwood, the latter is the only part fit for practical use, and from it, of course, the specimens should be taken. The butt also appears to afford timber of greater density and strength than the top. In pine trees, Mr. Fincham found that the pieces taken from the butt were about nine per cent. stronger than those taken from the top. Whether this holds true as to our own hardwoods it is impossible to say, but still as it is probably a factor affecting the strength of timber, the point should be noted in connection with experiments.

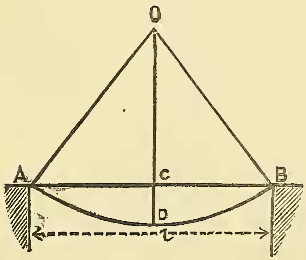
4. *Length of time seasoned.*—The process of seasoning affects different kinds of timber in opposite ways, making some stronger, others weaker. Buffon found that oak timber lost strength in the course of seasoning, and was accustomed to experiment upon it the third day after it was felled. Mr. James Mitchell, on the other hand, finds that blue gum is strengthened by seasoning, as will be shown by the following extract from Baron von Mueller's *Eucalyptographia.* The specimens were 7 feet long and 2 inches square:—

Length of Time Seasoned.	Modulus of Rupture in lbs.
8 months	13,270
2 to 3 years	16,860
3 years	17,670
4 to 5 years	16,970
20 years	20,940

Mr. Laslett, again, in his work upon "Timber and Timber Trees," shows by experiment that the resistance to crushing force in oak is greater when seasoned than when green, but that the transverse strength of different kinds of pine trees is greater when green than when dry.

5. *Deflection as affecting the bending moment of a beam.*—The customary formula for the bending moment of a beam, loaded in the middle and supported at each end, is $\frac{wl}{4}$, where w is the weight applied and l the length of the beam between the points of support. Now this formula expresses the bending moment only so long as the beam retains its original form and position, for whenever deflection begins two new elements are introduced, which affect the result. In the first place, the three forces acting on the beam—viz., the load and the reactions of the supports—cease to act in parallel lines; and in the second place the beam is lengthened by moving over the points of support as it deflects.

Barlow, in his work upon the "Strength of Materials," notices the effect of this new factor, and explains by it what was formerly an anomaly in the behaviour of loaded beams—viz., that the strain increases in a ratio higher than the direct ratio of the lengths. No doubt this is the explanation, for it is very evident that it will require a much less weight to produce the same strain in a beam when highly deflected than when straight. In cases, then, of large deflection the formula $\frac{wl}{4}$ is misleading, and, although sufficiently accurate for ordinary practical use, should certainly be replaced in all cases of experiment by the formula $\frac{wl}{4}$ Sec. $^2\theta$, θ being the angle of deflection. I obtained this result by the simple application of the resolution of forces, and as this method is much shorter and less involved than that given by Barlow, I include it in this paper:—



Let ADB be the beam loaded in the centre with a load w. Let $AB = l$ and θ the angle of deflection. The reactions at A and B will be at right angles to the inclination of the beam at these points, and may be represented by the lines AO BO. Producing the strain in the beam at the point D there is:—

1st, the vertical component of the reaction at the abutments multiplied by the distance at which the force acts—viz.,

$$\frac{w}{2} \times \frac{l}{2} = \frac{wl}{4}$$

2nd, the horizontal component of the reaction acting on the beam as if it were a long column, multiplied by the distance at which it acts—viz.,

$$\frac{w}{2} \tan. \theta \times \frac{l}{2} \tan. \theta = \frac{wl}{4} \tan.^2 \theta$$

and adding this to the former we get

$$\frac{wl}{4} \times \frac{wl}{4} \tan.^2 \theta = \frac{wl}{4} (1 + \tan.^2 \theta) = \frac{wl}{4} \sec.^2 \theta.$$

6. *Size of piece tested.*—It is the practice to assume that the strength of timber as a tie, beam, or column varies according to the sectional area exposed to the strain, in which case the size of the specimens tested to ascertain the strength of any timber, would not affect the result. This, however, does not appear to be the case, for from a comparison of experiments upon large and small scantlings, the results tend to prove, at all events in the case of beams, that the smaller the dimensions of the piece tested the higher proportionately is the moment of resistance.

If any variation were to be looked for, the contrary result might have been expected, for in cutting the wood, fibres which might not run exactly along the line of the piece would be cut through and their support lost, and in small pieces the ratio of the surface to the interior being so much greater than in large pieces the weakening result would be proportionately felt. It might be said, on the other hand, that in small pieces defects would not be so likely to occur, but I do not attach much weight to this explanation, as were this the cause of the anomaly all large pieces tested would require to be subject to these defects in a uniform way and reduced thereby to a corresponding state of weakness, a state of matters highly improbable. Without attempting to explain the reason, I shall simply place on record the facts which seem to establish the proposition.

Tensile strength.—Sufficient data is not obtainable to warrant any conclusions being arrived at with regard to tensile strength, although Laslett, who tested pieces many times larger than any other experimenter, invariably obtained results very much lower.

Transverse strength.—The following table shows results which appear to establish the proposition in question in regard to transverse strength; the most interesting point in which is the difference between the results for ironbark as found by the Engineer-in-chief of N.S.W. and the Railway-bridge Commission on the one hand with 12 in. x 12 in. beams, and Fowkes, Laslett, Tredgold, and Sydney Mint on the other hand, with pieces whose dimensions were 2 in. x 2 in.:—

TRANSVERSE STRENGTH.

Timber.	Scantling.	Mod. of Rupture.	Authority.
Memel Deal	9″ x 6″ x 17′	4,300	Tredgold
	1″ x 1″ x 2½′	9,810	
Baltic Fir	12″ x 9″ x 17′	3,200	Tredgold
	3″ x 3″ x 4′	10,400	
Red Gum	10¼″ x 7″ } x 14′ 8″ 11½″ x 8½″ }	8,800	Vict. Rly. Dept.
	2″ x 2″ x 2′	11,700	Mueller
British Oak	8·57″ x 8·57″ } x 10′ 8½″	9,130	Barlow
	7·50″ x 7·50″ }	9,280	
	6·43″ x 6·43″ }	8,680	
	5·35″ x 5·35″ }	9,530	
	4·28″ x 4·28″ }	9,550	
	2″ x 2″ x 6′	10,800	Laslett
Ironbark, N.S.W.	12″ x 12″ x 26′	13,953	Engr. chf. N.S.W.
	12″ x 12″ x 29·6′	12,222	Rly. Bdgs. Comn.
	2″ x 2″ x 4′	18,000	Sydney Mint
	2″ x 2″ x 1′	18,000	Fowkes
	2″ x 2″ x 7′	22,000	Laslett
	2″ x 2″ x 1′	24,100	Tredgold

Resistance to crushing.—Here comparisons are impossible. Barlow considered that the strength increased in a higher ratio than that of the area, whilst Tredgold took the opposite view. A series of experiments upon sets of blocks of varying area carried out by some one person would be the only way to settle the question satisfactorily.

These are the six minor conditions which it is necessary to record in connection with any series of experiments, in addition to which, of course, the particular species of timber to which each piece tested belongs must be thoroughly established. Local or popular names are almost valueless for the purpose; the true botanical nomenclature must be used. Some of the most extensive series of experiments carried out in Britain and in these colonies fail lamentably in this respect, and work which must have taken much time, and cost much money, is thus seriously diminished in value. As far as the work of experimenting itself is concerned it should embrace the following lines of inquiry, and in each case should be made upon timber both in its green state and when seasoned:—Weight, resistance to crushing along and across the grain, tensile strength, transverse strength, elasticity, resistance to shearing along and across the grain, and durability.

In view of the early establishment in our University of a complete testing machine, it is to be hoped that the coming year may see some good and systematic work done in the direction of timber testing. This should not prevent others, however, who have no apparatus from assisting in the work, for the more numerous the experiments the nearer to the truth do we arrive. All that is necessary is the inclination for the work, coupled with care and patience in carrying it out. The roughest bushman in the interior, breaking a few sticks with weights, and telling us all that is to be known about these sticks and about these weights, adds to the knowledge of the world, and his rough work, if only careful, true, and full, may rank with that of high officials who work in dockyards or laboratories with perfect machines and paid assistants. He may even rank before them as a benefactor if his work be complete, theirs imperfect, in the respect that complete knowledge, however limited, is truth, and is established for ever, whilst imperfect knowledge, however extensive, may only lead us into error and confusion.